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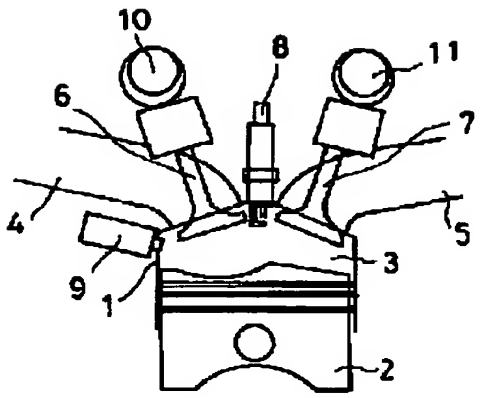
(54) **COMBUSTION CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE**

(57) Abstract:

PROBLEM TO BE SOLVED: To prevent generation of knocking by performing spark ignition combustion at a low compression ratio side of a switching region and performing self ignition combustion at a high compression ratio side, at the time of switching combustion, in a device in which the self ignition combustion is performed with a high compression ratio at the time of low load operation and the spark ignition combustion is performed with a low compression ratio at the time of high load operation.

SOLUTION: At the time of high load operation, an opening timing of an intake valve 6 is set earlier than a top dead center, a closing timing of an exhaust valve 7 is set later than the top dead center, and the intake and exhaust valves 6, 7 are overlapped with each other. Simultaneously, the closing timing of the intake valve 6 is set later than a bottom dead center to set to a low compression ratio, and spark ignition operation is carried out. On the other hand, at the time of low load operation a closing timing of an exhaust valve is set earlier than the top dead center an opening timing of the intake valve 6 is set later than the top dead center, a minas over lapping is set, and self ignition operation is carried out while aiming at inside EGR. In an intermediate compression ratio cycle at the switching region between self ignition and spark ignition combustion, spark ignition combustion is performed at a low compression ratio side of a switching region, self ignition combustion is performed at a high compression ratio side so as to suppress generation of knocking.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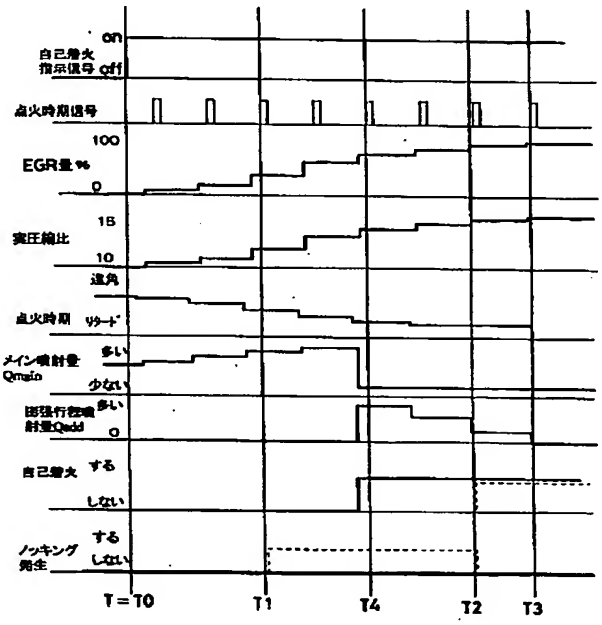
(54)【発明の名称】　内燃機関の燃焼制御装置

(57)【要約】
【課題】　運転領域によって高圧縮比での自己着火燃焼と低圧縮比での火花点火燃焼を切換える内燃機関において、切換え途中での運転性を向上させる。
【解決手段】　自己着火燃焼と火花点火燃焼の切換え時の中間圧縮比サイクルにおいて、切換え域の低圧縮比側では、点火時期を遅らせると共に、発生トルクが略同一となるようにメイン噴射量を増量する。切換え域の高圧縮比側では、膨張行程噴射、又は、マイナスオーバラップ期間中の噴射と点火により、作動ガス温度を上昇させ、また火花点火を併用する。



【特許請求の範囲】
【請求項１】低負荷において高圧縮比で自己着火燃焼、高負荷において低圧縮比で火花点火燃焼を行う内燃機関の燃焼制御装置において、
自己着火燃焼と火花点火燃焼の切換え時の中間圧縮比サイクルにおいて、切換え域の低圧縮比側では点火時期を調整した火花点火燃焼、切換え域の高圧縮比側では自己着火燃焼を行わせる切換え時制御手段を設けたことを特徴とする内燃機関の燃焼制御装置。
【請求項２】前記切換え域の低圧縮比側では、点火時期調整手段により、点火時期を遅らせると共に、発生トルクが略同一となるよう、燃料噴射量調整手段により、燃料噴射量を調整することを特徴とする請求項１記載の内燃機関の燃焼制御装置。
【請求項３】点火時期の遅延量は、圧縮比が高いほど大きくすることを特徴とする請求項２記載の内燃機関の燃焼制御装置。
【請求項４】前記切換え域の高圧縮比側では、作動ガス温度上昇手段により、作動ガス温度を上昇させることを特徴とする請求項１～請求項３のいずれか１つに記載の内燃機関の燃焼制御装置。
【請求項５】前記作動ガス温度上昇手段は、ピストンの膨張行程で追加の燃料を噴射するものであることを特徴とする請求項４記載の内燃機関の燃焼制御装置。
【請求項６】自己着火燃焼時に吸気弁と排気弁のオーバラップがマイナスになるように調整する可変動弁装置を備え、
前記作動ガス温度上昇手段は、ピストンの膨張行程で追加の燃料を噴射するものであることを特徴とする請求項４記載の内燃機関の燃焼制御装置。
【請求項７】自己着火燃焼時に吸気弁と排気弁のオーバラップがマイナスになるように調整する可変動弁装置を備え、
前記作動ガス温度上昇手段は、マイナスオーバラップ期間中のピストンの上昇行程で追加の燃料を噴射し、かつマイナスオーバラップ期間中に点火プラグを作動させて、追加の燃料を燃焼させるものであることを特徴とする請求項４記載の内燃機関の燃焼制御装置。
【請求項８】追加の燃料噴射量は、圧縮比が高いほど少なくすることを特徴とする請求項５～請求項７のいずれか１つに記載の内燃機関の燃焼制御装置。
【請求項９】追加の燃料噴射量は、ＥＧＲ量が多いほど少なくすることを特徴とする請求項５～請求項８のいずれか１つに記載の内燃機関の燃焼制御装置。
【請求項１０】前記切換え域の高圧縮比側でも点火を行い、かつその点火時期は圧縮比が高いほど遅らせることを特徴とする請求項１～請求項９のいずれか１つに記載の内燃機関の燃焼制御装置。
【請求項１１】自己着火燃焼時の圧縮比は、それだけで自己着火燃焼が可能な圧縮比とすることを特徴とする請求項１～請求項１０のいずれか１つに記載の内燃機関の燃焼制御装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、例えば自動車用の４サイクル型の火花点火式内燃機関で、特に特定の運転領域にて自己着火燃焼を行わせる内燃機関の燃焼制御装置に関する。
【０００２】
【従来の技術】従来の自己着火運転領域を有する内燃機関としては、例えば以下のようなものがある。
【０００３】２サイクル型の火花点火式内燃機関の分野では、部分負荷時における燃焼不安定を解消すると共に、ＨＣ（炭化水素）排出量の低減を図るために、シリンダ内における自己着火燃焼を積極的に利用した技術が提案されている。例えば、１９９４年７月１日発行の「ＨＯＮＤＡ　Ｒ&Ｄ　Ｔｅｃｈｎｉｃａｌ　Ｒｅｖｉｅｗ」には、低負荷時に排気通路の一部を遮断することによってシリンダ内の残留ガス濃度を高めて、圧縮行程開始時のシリンダ内圧を高め、自己着火の燃焼時期を制御する例が記載されている。
【０００４】自己着火は、作動ガスの温度と圧力があるレベル以上になる必要がある。その手段として、上記のようにＥＧＲガスを大量に使用したり、圧縮比を高めたり、あるいは、両者を併用することにより、自己着火を安定して起こす必要がある。
【０００５】その狙いで、本出願人から、このような自己着火を４サイクル型の火花点火式内燃機関において積極的に利用するための一つの例について、発明が提供されている。
【０００６】その発明は、特願平１０－２３５７３０号であり、吸気弁及び排気弁に、その作動期間やリフト量を可変にする可変動弁装置を備え、これにより、通常の火花点火運転時には、低圧縮比にし、自己着火運転時には、吸気弁と排気弁のオーバラップをマイナスにして、排気の一部をシリンダ内に閉じ込め、いわゆる内部ＥＧＲ量を多く確保して、次のサイクルの作動ガス温度を高めると共に、吸気弁の閉時期を下死点付近にして、有効圧縮比を高くとり、圧縮上死点付近での圧力を極力高くすることで、圧縮温度と圧力の両方を自己着火が安定して起こるレベルにすることにより、自己着火を容易に安定して起こさせるものである。
【０００７】
【発明が解決しようとする課題】しかしながら、火花点火運転時と自己着火運転時で、圧縮比やＥＧＲ量の要求が異なるため、自己着火運転領域が限られている場合には、運転状態に応じて火花点火と自己着火を切換える必要があり、そのため、圧縮比やＥＧＲ量などを切換える必要がある。その際、どうしても切換えの速度がエンジンの次のサイクルまでに終了するほど速くないために、

例えば、圧縮比が火花点火で要求される圧縮比１０と自己着火で要求される圧縮比１５の中間の値になるサイクルが出てくる。

【０００８】このような切換え時の中間圧縮比では、圧縮比やＥＧＲ量は自己着火を起こすに不十分であり、しかも、圧縮比やＥＧＲ量は、火花点火時期が通常の火花点火時期設定のままではノッキングを起こすレベルになっているのである。つまり、このままでは、火花点火運転モードと自己着火運転モードの切換え時に必ずノッキングが起こることになり、運転者にとり不快であるばかりか、エンジン本体の損傷にも繋がる可能性のあることになる。

【０００９】その意味で、このような中間圧縮比では、自己着火させるか、火花点火させるかして、正常な燃焼をさせる必要がある。例えば、自己着火させようとすると、作動ガス温度を高める必要があり、その手段としては、例えば特開平１０－７３０１９号や特開平１０－１２２０１５号にあるように、ピストンの膨張行程に燃料を噴射することで排気ガス温度を高める手段がある。

【００１０】しかし、これらの発明は、排気管下流の触媒を昇温する目的の発明であり、本発明のように、次のサイクルの作動ガス温度を上昇させる課題や目的に対しては、以下に述べるようにそれだけでは不十分である。つまり、排気ガス温度が高くなっても、それらがすべて次のサイクルのエンジンの作動ガスになるわけではなく、いわゆる外部ＥＧＲとしてＥＧＲ通路を経て吸気ポートに送られても、時間遅れがあり、次のサイクルには間に合わない。従って、オーバラップ期間中に吸気に吸い戻される排気ガスとして、あるいは、シリンダ内に残留するガスとして、温度が高くなった分が次のサイクルのガス温度上昇に使われるだけで、燃費の悪化に対する作動ガス温度の上昇という点では効率が必ずしも良くない。

【００１１】一方、特開平１０－１９６４２４号には、ピストンの圧縮のみでは自己着火が起きないようにし、他の手段でピストンの圧縮上死点付近で温度を上昇させて、自己着火を安定して起こさせる発明がある。これによれば、中間圧縮比において、圧縮比やＥＧＲ量が不足して自己着火が起きないサイクルでも自己着火が起こせるが、実はこの機関の基本的な圧縮比は自己着火が起きないほど低く、したがって、サイクルの熱効率は低くならざるを得ない。

【００１２】本発明は、内燃機関の熱効率を高くするために、高い圧縮比で運転を可能にする内燃機関を狙っており、サイクルの熱効率が低下する手段では、その目的を達成できない。

【００１３】すなわち、自己着火運転時には、極力高い圧縮比で、サイクル熱効率を極力高くする内燃機関を実現する狙いが本発明にはあり、それに伴い、自己着火運転領域以外の領域では通常のそれよりも低い圧縮比で運転せざるを得ない本発明独特の特徴が生起される。

【００１４】つまり、自己着火運転時にはベースエンジンの圧縮比はサイクル熱効率の高い、それだけで自己着火が起こる高圧縮比になることが本発明の前提であり、これが特開平１０－１９６４２４号との大きな差異点であり、特開平１０－１９６４２４号にある手段では本発明の目的が達成できないことは明白である。

【００１５】無論、本発明では、自己着火を起こさせるために、圧縮比と内部ＥＧＲの両方を活用する内燃機関も対象としているが、内部ＥＧＲは作動ガスの供給される以前からシリンダ内にあって、シリンダ内のガス温度を高く保っている。これは、可燃混合気に対して付加的に温度上昇を与えるとは言えず、かつ本発明にあるような直接噴射の場合には、可燃混合気の温度上昇でなく、内部ＥＧＲガスの作用として、吸入空気温度を高めることになるので、可燃混合気を付加的に温度を高めることにはなっていないことは明白である。

【００１６】本発明は、以上のような状況の下に、自己着火運転と火花点火運転の切換え時に、切換え手段の時間遅れがあるために、いくつかの過渡的なサイクルにおいて、そのサイクルの有効圧縮比やＥＧＲ量が中間的になり、自己着火が起きずに、ノッキングが発生し、運転者や同乗者に対して不快であるばかりか、エンジンの安定性が損なわれ、運転性が悪化する可能性があり、また、ノッキングの程度が激しい場合は、エンジン本体の損傷を生起する可能性があるという問題点を解決することを目的とする。

【００１７】

【課題を解決するための手段】このため、請求項１に係る発明では、図１に示すように、低負荷において高圧縮比で自己着火燃焼、高負荷において低圧縮比で火花点火燃焼を行う内燃機関の燃焼制御装置において、自己着火燃焼と火花点火燃焼の切換え時の中間圧縮比サイクルにおいて、切換え域の低圧縮比側では点火時期を調整した火花点火燃焼、切換え域の高圧縮比側では自己着火燃焼を行わせる切換え時制御手段を設けたことを特徴とする。

【００１８】請求項２に係る発明では、請求項１に係る発明において、前記切換え域の低圧縮比側では、点火時期調整手段により、点火時期を遅らせると共に、発生トルクが略同一となるよう、燃料噴射量調整手段により、燃料噴射量を調整することを特徴とする。

【００１９】請求項３に係る発明では、請求項２に係る発明において、点火時期の遅延量は、圧縮比が高いほど大きくすることを特徴とする。請求項４に係る発明では、請求項１～３に係る発明において、前記切換え域の高圧縮比側では、作動ガス温度上昇手段により、作動ガス温度を上昇させることを特徴とする。

【００２０】請求項５に係る発明では、請求項４に係る発明において、前記作動ガス温度上昇手段は、ピストン

の膨張行程で追加の燃料を噴射するものであることを特徴とする。

【００２１】請求項６に係る発明では、請求項４に係る発明において、自己着火燃焼時に吸気弁と排気弁のオーバラップがマイナスになるように調整する可変動弁装置を備え、前記作動ガス温度上昇手段は、ピストンの膨張行程で追加の燃料を噴射するものであることを特徴とする。ここで、マイナスのオーバラップとは、排気弁の閉時期を上死点より早くし、吸気弁の開時期を上死点より遅くして、上死点付近で吸気弁及び排気弁が共に閉じている期間を設けることをいう。

【００２２】請求項７に係る発明では、請求項４に係る発明において、自己着火燃焼時に吸気弁と排気弁のオーバラップがマイナスになるように調整する可変動弁装置を備え、前記作動ガス温度上昇手段は、マイナスオーバラップ期間中のピストンの上昇行程で追加の燃料を噴射し、かつマイナスオーバラップ期間中に点火プラグを作動させて、追加の燃料を燃焼させるものであることを特徴とする。

【００２３】請求項８に係る発明では、請求項５～７に係る発明において、追加の燃料噴射量は、圧縮比が高いほど少なくすることを特徴とする。請求項９に係る発明では、請求項５～８に係る発明において、追加の燃料噴射量は、ＥＧＲ量が多いほど少なくすることを特徴とする。

【００２４】請求項１０に係る発明では、請求項１～９に係る発明において、前記切換え域の高圧縮比側でも点火を行い、かつその点火時期は圧縮比が高いほど遅らせることを特徴とする。

【００２５】請求項１１に係る発明では、請求項１～１０に係る発明において、自己着火燃焼時の圧縮比は、それだけで自己着火燃焼が可能な圧縮比とすることを特徴とする。

【００２６】

【発明の効果】請求項１に係る発明によれば、自己着火燃焼と火花点火燃焼の切換え時の中間圧縮比サイクルにおいて、切換え域の低圧縮比側では点火時期を調整した火花点火燃焼、切換え域の高圧縮比側では自己着火燃焼を行わせることにより、自己着火燃焼と火花点火燃焼の切換え中にノッキングが発生することなく、両運転領域を円滑に移行できるので、良好な運転性や静粛性を得ることができるという効果が得られる。

【００２７】請求項２に係る発明によれば、切換え域の低圧縮比側では、点火時期を遅らせると共に、発生トルクが略同一となるよう、燃料噴射量を調整することにより、ノッキングを回避できるのみならず、安定した回転を確保することができる。

【００２８】請求項３に係る発明によれば、点火時期の遅延量は、圧縮比が高いほど大きくすることで、ノッキング回避効果を適切なものとすることができる。請求項４に係る発明によれば、切換え域の高圧縮比側では、作動ガス温度上昇手段により、作動ガス温度を上昇させることにより、安定して自己着火を起こさせることができる。

【００２９】請求項５に係る発明によれば、ピストンの膨張行程で追加の燃料を噴射することによって、作動ガス温度を確実に上昇させることができ、安定して自己着火を起こさせることができる。

【００３０】請求項６に係る発明によれば、自己着火燃焼時にマイナスのオーバラップになるように調整した上で、ピストンの膨張行程で追加の燃料を噴射することによって、作動ガス温度を更に確実に上昇させることができ、安定して自己着火を起こさせることができる。

【００３１】請求項７に係る発明によれば、自己着火燃焼時にマイナスのオーバラップになるように調整した上で、マイナスオーバラップ期間中のピストンの上昇行程で追加の燃料を噴射し、かつマイナスオーバラップ期間中に点火プラグを作動させて、追加の燃料を燃焼させることによって、作動ガス温度を更に確実に上昇させることができ、安定して自己着火を起こさせることができる。

【００３２】請求項８に係る発明によれば、追加の燃料噴射量は、圧縮比が高いほど少なくすることで、適切に制御できる。請求項９に係る発明によれば、追加の燃料噴射量は、ＥＧＲ量が多いほど少なくすることで、適切に制御できる。

【００３３】請求項１０に係る発明によれば、切換え域の高圧縮比側でも点火を行い、かつその点火時期は圧縮比が高いほど遅らせることで、自己着火が起きなかった場合でも、火花点火により燃焼を起こさせ、運転性や排気の悪化を防止することができる。

【００３４】請求項１１に係る発明によれば、自己着火燃焼時の圧縮比は、それだけで自己着火燃焼が可能な圧縮比とすることで、熱効率を極力高くすることができる。

【００３５】

【発明の実施の形態】以下、本発明の実施の形態について説明する。図２は本発明の一実施形態を示す内燃機関の概略図である。

【００３６】まず構成を説明すると、エンジンのシリンダ１とピストン２により画成される燃焼室３には、吸気ポート４及び排気ポート５の開口部に、吸気弁６及び排気弁７を備えている。また、燃焼室３に臨むように、火花点火用の点火プラグ８を備えると共に、直噴式の燃料噴射弁９を備えている。

【００３７】吸気弁６及び排気弁７を駆動する各カムシャフトには、各カムによる吸気弁６及び排気弁７の作動期間とリフト量の両方を制御可能な可変動弁装置１０，１１が設けられている。尚、可変動弁装置１０，１１のアクチュエータとしては、例えば油圧又は電動モータな

どが用いられる。

【００３８】これにより、通常の火花点火運転時には、図３（１）に示すように、吸気弁の開時期を上死点（ＴＤＣ）より早く、排気弁の閉時期を上死点より遅くして、吸気弁と排気弁のオーバラップを持たせ、同時に、吸気弁の閉時期を下死点（ＢＤＣ）よりも遅くして、圧縮比をノッキングしない程度の低圧縮比、例えば１０程度に設定する。

【００３９】自己着火運転時には、吸気弁と排気弁の作動期間とリフト量の制御により、図３（４）に示すように、排気弁の閉時期を上死点より早く、吸気弁の開時期を上死点より遅くして、マイナスオーバラップを設ける。すなわち、排気弁を排気行程の途中で閉じ、排気ガスの一部をシリンダ内にとどまらせて（内部ＥＧＲ）、上死点の前後で圧縮・膨張させ、シリンダ内圧力が吸気ポート圧力程度になったときに吸気弁を開いて新しい空気をシリンダ内に吸入する。これにより、新しい空気はその１つ前のサイクルの残留ガスにより加熱される。同時に、吸気弁の閉時期は、下死点付近として、圧縮比を高圧縮比（このエンジンでの最大有効圧縮比）、例えば１５程度に設定する。従って、新しい空気は残留ガスで加熱されると共に、圧縮比を高くとれるので、圧縮上死点付近での温度と圧力が自己着火を安定的に起こさせるようなレベルに達することが可能となる。

【００４０】燃料噴射弁９は、直噴式で、これにより後述するメイン噴射及び補助噴射の両方を行うようにしているが、吸気ポート４にて燃料を噴射する燃料噴射弁と、直噴式の燃料噴射弁とを設けて、メイン噴射を吸気ポート側の燃料噴射弁、補助噴射を直噴式の燃料噴射弁によって行うようにしてもよい。

【００４１】点火プラグ８、燃料噴射弁９の他、吸気弁６と排気弁７の可変動弁装置１０，１１は、図示しないコントロールユニットに接続され、該コントロールユニットからの信号に基づいて制御される。

【００４２】コントロールユニットは、例えば、エンジン回転数、アクセルペダル開度（トルク）などの信号を入力し、図４に示すような低負荷側の自己着火運転領域と高負荷側の火花点火運転領域の判別を行う。更に、吸気弁６や排気弁７の作動をモニタする信号を入力し、例えば、吸気弁の閉時期からサイクル毎の有効圧縮比の算出、吸気弁の開時期と排気弁の閉時期から、オーバラップ量の算出と内部ＥＧＲ量の算出を行う。

【００４３】次に作用を説明する。まず、図５において、従来の内燃機関の場合の過渡特性挙動を、火花点火運転領域から自己着火運転領域に移行する場合を例にとって、説明する。自己着火運転領域から火花点火運転領域に移行する場合は、図５の逆をたどることになる。

【００４４】図５の時刻Ｔ０において、自己着火に移行する判断がコントロールユニットで行われ、自己着火指示信号がＯｎとなる。それに従い、吸気弁と排気弁の作動を変更するために、可変動弁装置において油圧又は電動モータなどのアクチュエータが動きはじめ、圧縮比やＥＧＲ量（内部ＥＧＲ量）がサイクル毎に変化していくが、Ｏｎとなったその次のサイクルではまだ、圧縮比やＥＧＲ量もほとんど火花点火運転時のままであり、アクチュエータの作動所要時間（Ｔ０～Ｔ３）による遅れのため、圧縮比とＥＧＲ量はサイクル毎に徐々に変化し、最終的に自己着火が安定して起こるのは、例えば８サイクル目の時刻Ｔ３になる。

【００４５】図５の時刻Ｔ１において、圧縮比とＥＧＲ量がやや高くあるいは多くなるので、火花点火時期がそのままでは、ノッキングが起こる。そのままカムの移行を続けると、時刻Ｔ２において、圧縮比とＥＧＲ量が自己着火を起こさせるレベルに達し、自己着火が起こり、ノッキングはなくなる。

【００４６】すなわち問題になるのは、この時刻Ｔ１からＴ２までの間である。この間は、圧縮比とＥＧＲ量はそれぞれ高くあるいは多くなる過程にありながら、自己着火を起こすには不足で、点火時期が低圧縮比での設定のままの場合は、ノッキングを起こしてしまう領域である。

【００４７】図６に本発明の作用を示す。本発明は、時刻Ｔ１とＴ２の間に注目しており、この間を２つに分け、中間圧縮比での低圧縮比側と高圧縮比側に分ける。時刻Ｔ４をその分ける時刻とする。

【００４８】時刻Ｔ１とＴ４の間（制御上は時刻Ｔ０とＴ４の間）では、図３（２）に示すような切換え途中の吸排気弁の開閉状況であるので、まだ、圧縮比もＥＧＲ量も比較的低くかつ少ない。従って、火花点火をさせるが、点火時期をリタード（遅延）させる。この際、図７に示すように、点火時期リタードによりノッキング限界となる圧縮比が高くなり、ノッキングを回避できる。

【００４９】その一方、同じく図７に示すように、点火時期リタードにより熱発生時期が遅れるため、サイクル効率が悪化して、トルクが減少する。そのため、そのトルク減少分ΔTorque を補うために、吸気行程でのメイン噴射量Ｑmainを増量する。これにより空燃比がリッチ側となり、更にノッキング回避効果も大きくできる。このメイン噴射量Ｑmainの増量分は、圧縮比が高いほど、つまりＴ４に近いほど、多くすることは言うまでもない。

【００５０】次に時刻Ｔ４になると、すなわち、時刻Ｔ４とＴ２の間（制御上は時刻Ｔ４とＴ３の間）では、図３（３）に示すような切換え途中の吸排気弁の作動状況となるので、圧縮比やＥＧＲ量が比較的高くかつ多くなる。従って、補助的な作動ガス温度上昇手段で作動ガス温度を上昇させて、自己着火燃焼させる。

【００５１】図６では、作動ガス温度上昇手段として、ピストンの膨張行程で追加の燃料（補助燃料）を噴射する手段を用いて、排気温度を高める例を示している。追

加の燃料噴射量（膨張行程噴射量）Ｑadd は、Ｔ４付近で最も多く、それ以降減量され、切換えが完了する時刻Ｔ３でゼロになる。これは、圧縮比やＥＧＲ量がＴ４からＴ３になるにつれ高くかつ多くなり、時刻Ｔ３の手前のＴ２で自己着火が起こるほど十分なレベルに達するためである。

【００５２】図８に更に詳細に示すように、補助燃料は膨張行程に噴射され、それにより排気温度が高くなる。通常はオーバラップが少ないので、排気ガスが残留ガスとしてそれほど次のサイクルには回らず、単に膨張行程噴射するだけでは効果が得られにくいが、本実施形態では、マイナスオーバラップとしているため、Ｔ４からＴ３の間では、図３（３）に示すように、マイナスオーバラップがかなり大きくなり、排気ガスのより多くの一部が確実にシリンダ内にトラップされ、次のサイクルの作動ガス温度をかなり上昇させることができる。従って、本発明では、膨張行程噴射により、マイナスオーバラップ構成とすることで、有効に次のサイクルの作動ガス温度上昇を実現できている。

【００５３】また、この際、図６と図８にあるように、火花点火も併用する。この火花点火の点火時期は、圧縮比が高いほど、あるいはＥＧＲ量が多いほどリタードしていて、図８では上死点後に設定されている。これは、自己着火が起きなかった場合でも、火花点火により燃焼を起こさせ、エンジンが失火することなく、回り続けて、運転性や排気の悪化が起こることを防ぐためである。

【００５４】更に、図９には、膨張行程噴射とは別の作動ガス温度上昇手段として、マイナスオーバラップ期間中のピストンの上昇行程で追加の燃料（補助燃料）を噴射し、かつマイナスオーバラップ期間中に点火プラグを作動させて、追加の燃料を燃焼させる手段を用いた例を示す。

【００５５】これは、マイナスオーバラップ期間中に、燃料を直接噴射し、火花点火して燃焼させることにより、ＥＧＲガスの温度を更に上昇させて、少ないＥＧＲ量でも、新しい空気を十分加熱して自己着火を起こさせるようにするためである。

【００５６】この補助燃料噴射は、ピストンが排気行程で上昇する期間で、噴射した燃料が排気弁から吹き抜けないタイミングであり、かつ、マイナスオーバラップ期間中に噴射される。望ましくは、上死点前３０度から７０度付近とされる。

【００５７】点火は、マイナスオーバラップ中に行われ、望ましくは、上死点前後に行われる。あまり早い時期に点火すると、エンジンのマイナス仕事が増えるため、望ましくは、上死点前３０度より後に点火されるように設定される。

【００５８】このような補助的な作動ガス温度上昇手段は、マイナスオーバラップ構成特有のものであり、全ての噴射燃料がＥＧＲガスの温度上昇に使われるため効率が良い。また、点火時期を選ぶことにより、熱発生を上死点後にして、ピストンに対してプラスの仕事を行い、補助燃料噴射による燃費悪化を最小限にできる特徴がある。また、噴射量が多く、ＥＧＲガスの酸素が少ない場合、未燃ＨＣが生成するが、その生成した未燃ＨＣは、逆に燃焼中間生成物として、そのサイクルの自己着火を容易に起こす作用があるので、好都合である。従ってこの補助燃料の噴射量も、図６の膨張行程噴射量Ｑadd と同じく、Ｔ４付近で最大で、Ｔ３に近づくにしたがって少なくなり、Ｔ３ではゼロになるように設定される。

【００５９】高圧縮比自己着火運転モードから、低圧縮比火花点火運転モードに切換わる際は、上記の逆を行う。図１０は上記制御をフローチャートにより示したものである。

【００６０】ステップ１（図にはＳ１と記す。以下同様）では、運転領域を判別し、高負荷側の場合は、ステップ２へ進んで、低圧縮比での火花点火制御を行う。また、低負荷の場合は、ステップ３へ進んで、高圧縮比での自己着火燃焼制御を行う。

【００６１】また、ステップ４では、火花点火燃焼と自己着火燃焼との切換え域か否かを判定し、切換え域の場合は、次のように制御する（切換え時制御手段）。ステップ５で実圧縮比を判定し、低圧縮比側の場合は、ステップ６で点火時期をリタードさせる（点火時期調整手段）。また、ステップ７でメイン噴射量を増量する（燃料噴射量調整手段）。

【００６２】高圧縮比側の場合は、ステップ８で膨張行程噴射又はマイナスオーバラップ期間中の噴射と点火により作動ガス温度を上昇させる（作動ガス温度上昇手段）。また、ステップ９で火花点火を併用する。

【００６３】本発明の説明として、図３のマイナスオーバラップ構成の例で説明してきたが、その他の自己着火運転領域を伴う内燃機関の例として、メカニカルな可変圧縮比のみのシステム（バルブタイミングは変えない）が考えられる。この場合においても、圧縮比が上がっていく初期は、点火時期リタードで対応できるが、より圧縮比が上がると、もはや点火時期リタードでは出力が低下して対応できない。また、バルブタイミングが変更されないので残留ガス量が多くなく、排気温度を上昇させてもその効果は抑制されるが、自己着火の促進効果は得られる。この場合でも以下の作用を行う。

【００６４】低圧縮比火花点火運転モードから、高圧縮比自己着火運転モードに切換わる際、切換え指示直後から、圧縮比が上がるにつれてノッキングしやすくなるため、点火時期を遅らせて、ノッキングを抑制しつつ火花点火させる。

【００６５】更に圧縮比が上がると、ピストン膨張行程に追加の燃料を噴射し燃焼を起こさせ、次のサイクルへの残留ガスの温度を上昇させ、次のサイクルでの自己着

火を十分な高圧縮比でなくても起こさせる。

【００６６】更に圧縮比が上がると、追加の燃料噴射を止める。このとき、自己着火運転モードへの移行を完了したことになる。マイナスオーバラップのシステムに比べ、追加噴射燃料の全てが次のサイクルの吸気温度を上昇させるわけではないので、その温度上昇効率は劣る。

【００６７】しかし、圧縮比の応答速度を実用上十分速くすることにより、ノッキング抑制しつつ自己着火燃焼を実現できる。高圧縮比自己着火運転モードから、低圧縮比火花点火運転モードに切換わる際は、上記の逆を行う。

【００６８】また、他の例として、吸気弁のカム軸をひねることで圧縮比を調整する場合もある。この場合、低圧縮比ではバルブオーバラップは少なく、高圧縮比ではバルブオーバラップが大きくなり、より残留ガスが多くなる。この場合では、圧縮比が上がっていく初期は、点火時期のリタードで対応でき、より圧縮比が上がると、同時にオーバラップ量も大きくなっている。このため、排気ガスの温度を上昇させると次のサイクルへの残留ガス量が多いので、次のサイクルの吸気温度も上昇し、完全に圧縮比が上がらなくても、自己着火を起こすことができる。

【００６９】低圧縮比火花点火運転モードから、高圧縮比自己着火運転モードに切換わる際、切換え指示直後から、圧縮比が上がるにつれてノッキングしやすくなるため、点火時期を遅らせて、ノッキングを抑制しつつ火花点火させる。

【００７０】更に圧縮比が上がると、ピストン膨張行程に追加の燃料を噴射し燃焼を起こさせ、次のサイクルへの残留ガスの温度を上昇させ、次のサイクルでの自己着火を十分な高圧縮比でなくても起こさせる。このとき、バルブオーバラップ量も多くなっているので、次のサイクルの吸気ガス温度も上昇する。このため、圧縮比が完全に上昇しなくても、自己着火を起こすことができる。

【００７１】更に圧縮比が上がると、圧縮比のみでも自己着火が起こるので、追加の燃料噴射を止める。このとき、自己着火運転モードへの移行を完了したことになる。マイナスオーバラップのシステムに比べ、追加噴射燃料の全てが次のサイクルの吸気温度を上昇させるわけではないので、その温度上昇効率は劣るが、バルブタイミングが同じままのメカニカルな可変圧縮比システムに比べれば、温度上昇効率は高い。

【００７２】高圧縮比自己着火運転モードから、低圧縮比火花点火運転モードに切換わる際は、上記の逆を行う。以上のように、本実施形態に係る内燃機関の燃焼制御装置では、高圧縮比の自己着火と低圧縮比の火花点火の運転の切換え時において、切換え途中の中間圧縮比において、低圧縮比側では点火プラグによる点火時期をリタードしてノッキングを抑制すると共に、高圧縮比側では作動ガス温度を補助的かつ一時的な手段で上昇させて自己着火を起こさせるようにしたので、切換え中にノッキングが発生することなく、自己着火に移行できるので、良好な運転性や静粛性が保たれるという効果が実現される。

【００７３】この結果として、自己着火が安定して実現できるので、従来のように吸気通路の途中に設けられたスロットル弁によって、部分負荷時に吸入される新気の量を制限する必要がないため、吸入負圧に起因するポンピングロスの低減が可能となる。

【００７４】特に、自己着火時にマイナスオーバラップ構成にする場合には、圧縮比とＥＧＲ量が共に動くので、排気温度上昇、あるいは、吸気上死点での補助噴射燃料への点火などが、有効に次のサイクルの作動ガス温度の上昇に使われるという効果が得られる。但し、マイナスオーバラップにしない構成のエンジンでも、本発明による効果は実用上十分得られる。

【図面の簡単な説明】

【図１】　本発明の構成を示す機能ブロック図

【図２】　本発明の一実施形態を示す内燃機関の概略図

【図３】　可変動弁装置による自己着火運転と火花点火運転の切換え作動の一例を示す図

【図４】　自己着火運転領域と火花点火運転領域の一例を示す図

【図５】　従来の自己着火燃焼と火花点火燃焼の切換え時の制御を示す図

【図６】　本発明の自己着火燃焼と火花点火燃焼の切換え時の制御の一例を示す図

【図７】　点火時期リタードによるノック回避とトルク減少を示す図

【図８】　中間圧縮比の高圧縮比側の作用の一例を示す図

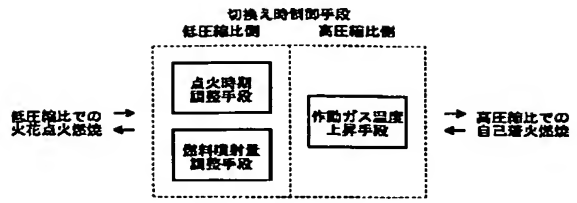
【図９】　マイナスオーバラップによる自己着火運転システムにおける切換え時の中間圧縮比の高圧縮比側の作用の一例を示す図

【図１０】　切換え制御の概略を示すフローチャート

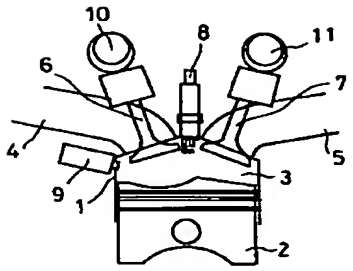
【符号の説明】

１　シリンダ
２　ピストン
３　燃焼室
４　吸気ポート
５　排気ポート
６　吸気弁
７　排気弁
８　点火プラグ
９　燃料噴射弁
１０，１１　可変動弁装置

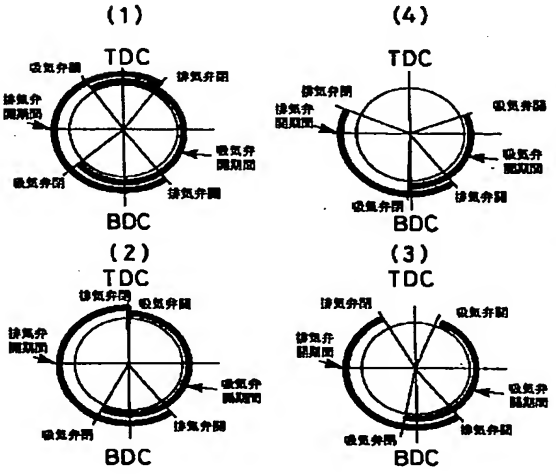
【図１】



【図２】



【図３】



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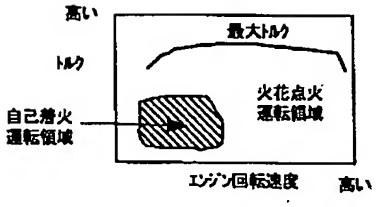

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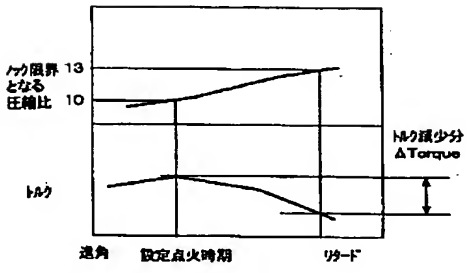

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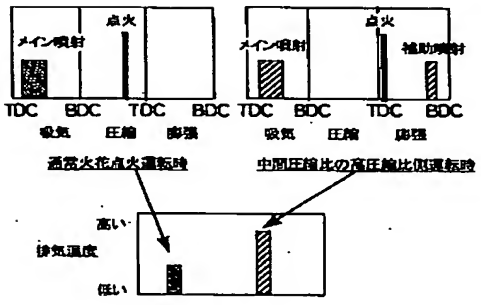

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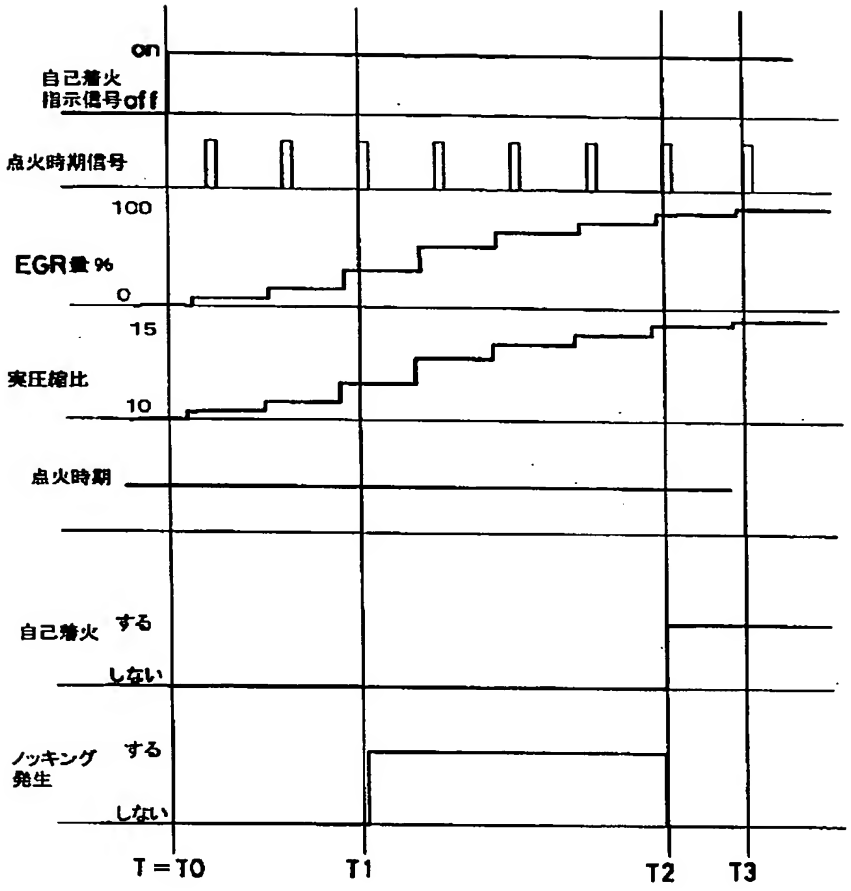
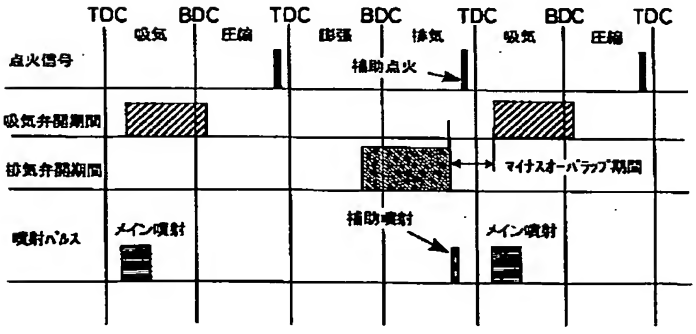
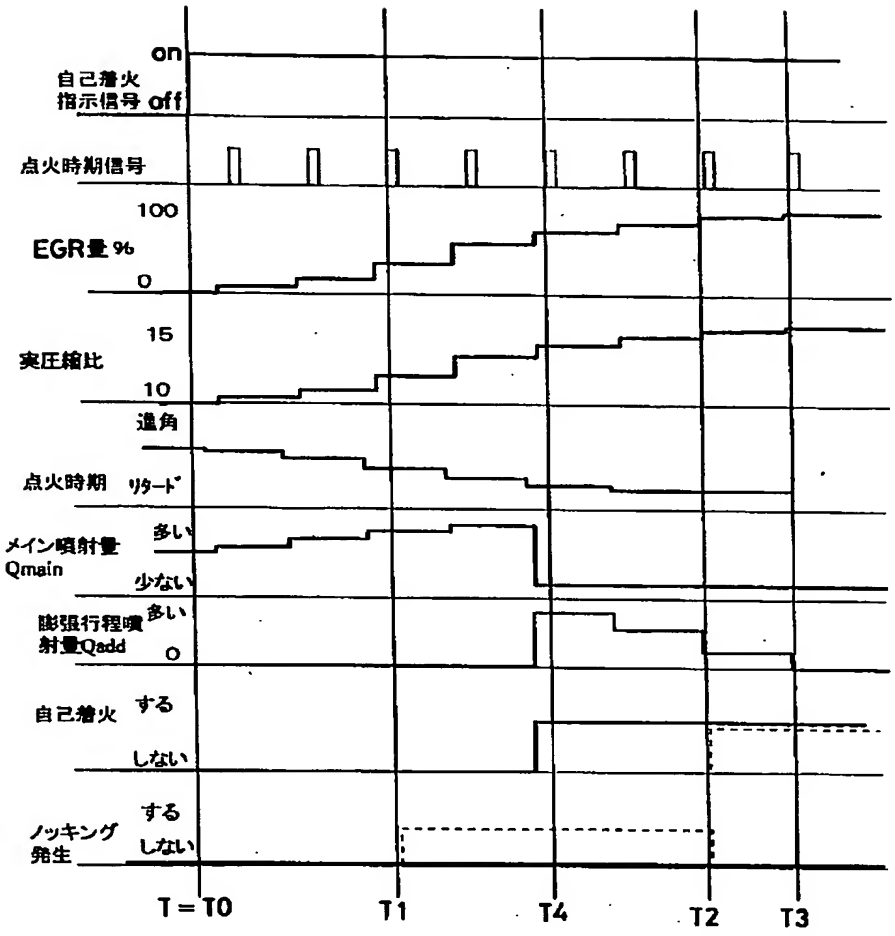

on
自己着火
指示信号off
点火時期信号
100
EGR量％
0
15
実圧縮比
10
点火時期
自己着火
する
しない
ノッキング
発生
する
しない
T＝T0
T1
T2
T3

【図９】


TDC
吸気
BDC
圧縮
TDC
膨張
BDC
排気
TDC
吸気
BDC
圧縮
TDC
点火信号
補助点火
吸気弁開期間
排気弁開期間
マイナスオーバラップ期間
噴射パルス
メイン噴射
補助噴射
メイン噴射

【図６】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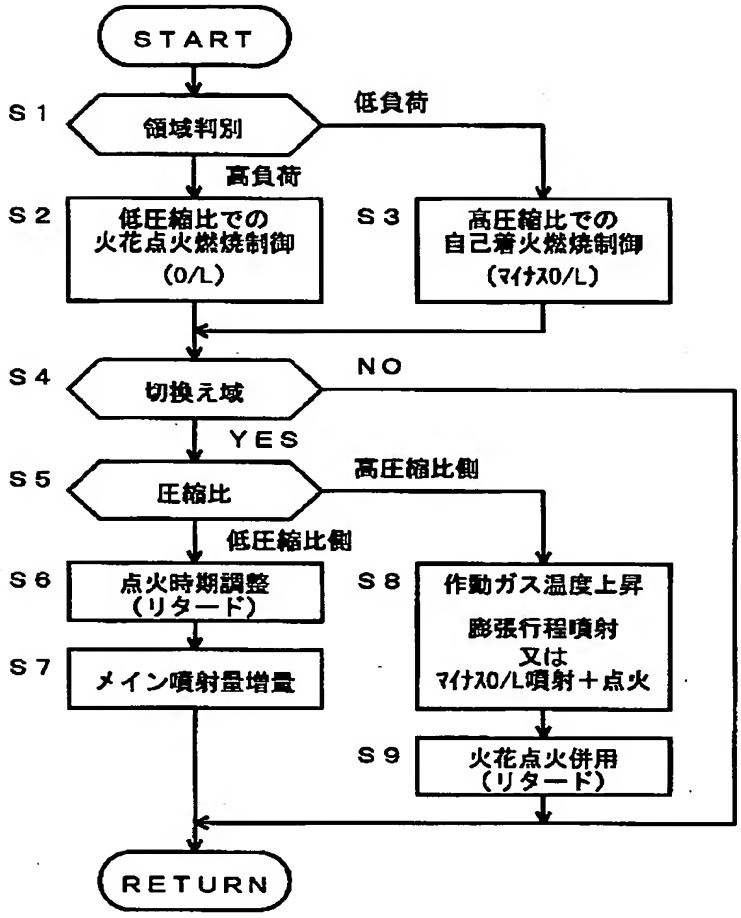
自己着火
指示信号 off
点火時期信号
100
EGR量 %
0
15
実圧縮比
10
遅角
点火時期 リタード
多い
メイン噴射量
Qmain
少ない
多い
膨張行程噴
射量Qadd
0
自己着火 する
しない
する
ノッキング
発生
しない
T＝T0
T1
T4
T2
T3

【図１０】



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EA07 GA05
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AG00
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GA00 GA06 GA26
3G092 AA01 AA02 AA06 AA11 AA12
BA08 BA09 BB01 BB06 BB13
DA01 DA02 DA03 DA12 DC09
DD03 DG05 DG08 EA01 EA02
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3G301 HA01 HA02 HA04 HA19 JA04
JA21 JA22 JA37 KA11 LA07
LB04 MA11 MA19 MA23 NE01
NE06 NE11 NE12 NE21 PB03A
PB05A PC05A PD15A PE09A
PE10A PE10Z PF03Z

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention is the jump-spark-ignition type internal combustion engine of the four-cycle mold for automobiles, and relates to the combustion control system of the internal combustion engine which makes self-ignition combustion perform in a specific operating range especially.
[0002]
[Description of the Prior Art] As an internal combustion engine which has a conventional self-ignition operating range, there is the following, for example.
[0003] In the field of the jump-spark-ignition type internal combustion engine of a two-cycle mold, while canceling the combustion instability at the time of a partial load, in order to aim at reduction of HC (hydrocarbon) discharge, the technology which used the self-ignition combustion in a cylinder positively is proposed. For example, the residual-gas concentration in a cylinder is raised, the cylinder internal pressure at the time of compression stroke initiation is raised, and the example which controls the combustion stage of self-ignition is indicated by by intercepting a part of flueway to "HONDA R&D Technical Review" of issue on July 1, 1994 at the time of a low load.
[0004] Self-ignition needs to become more than level with the temperature and the pressure of working medium. It is stabilized and it is necessary to cause self-ignition by using EGR gas in large quantities as mentioned above, raising a compression ratio, or using both together as the means.
[0005] By the aim, invention is offered from these people about one example for using such self-ignition positively in the jump-spark-ignition type internal combustion engine of a four-cycle mold.
[0006] The invention is Japanese Patent Application No. No. 235730 [ten to], and an inlet valve and an exhaust valve are equipped with the adjustable moving valve mechanism which makes adjustable the actuation period and amount of lifts. At the time of the usual jump-spark-ignition operation, by this While making it a low compression ratio, carrying out overlap of an inlet valve and an exhaust valve to minus, shutting up a part of exhaust air in a cylinder, securing many so-called amounts of internals EGR at the time of self-ignition operation and raising the working medium temperature of the following cycle It is stabilized easily and self-ignition is made to cause by carrying out the close stage of an inlet valve near a bottom dead point, taking a high effective compression ratio, and making both compression temperature and a pressure into the level to which self-ignition stabilized and happens by making high the pressure near a compression top dead center as much as possible.
[0007]
[Problem(s) to be Solved by the Invention] However, it is at the jump-spark-ignition operation and self-ignition operation time, and since the demands of a compression ratio or the amount of EGR(s) differ, when a self-ignition operating range is restricted, it is necessary to switch jump spark ignition and self-ignition according to operational status, therefore to switch a compression ratio, the amount of EGR(s), etc. The cycle which becomes the middle value of the compression ratio 10 as which a compression ratio is required by jump spark ignition, and the compression ratio 15 demanded by self-ignition since it is

never as quick as the speed of a change is completed by the engine next cycle in that case comes out.
[0008] The middle compression ratio at the time of such a change of the compression ratio or the amount of EGR(s) is inadequate for causing self-ignition, and, moreover, the compression ratio and the amount of EGR(s) have with it level which causes knocking while the jump-spark-ignition stage has been the usual jump-spark-ignition stage setup. That is, the way things stand, knocking will surely take place at the time of the change of jump-spark-ignition operation mode and self-ignition operation mode, and it may lead also to damage on about [being unpleasant] and an engine for an operator.
[0009] It is necessary to carry out normal combustion by carrying out self-ignition or carrying out jump spark ignition in such a middle compression ratio in the semantics. For example, it is necessary to raise working medium temperature, and as the means, when self-ignition tends to be carried out, as it is in JP,10-73019,A or JP,10-122015,A, for example, the means which raises exhaust gas temperature by injecting a fuel is in the expansion stroke of a piston.
[0010] However, these invention is invention to carry out the temperature up of the catalyst of an exhaust pipe lower stream of a river, and just it is inadequate [invention] so that it may state below like this invention to the technical problem and the purpose which raise the working medium temperature of the following cycle. That is, even if it does not become the working medium of the engine whose they are all the following cycles even if exhaust gas temperature becomes high and is sent to a suction port through an EGR path as the so-called exterior EGR, there is a time lag and it is not enough for the following cycle. Therefore, in respect of the rise of working medium temperature [as opposed to aggravation of fuel consumption only at being used for the gas-temperature rise whose part to which temperature became high is the following cycle as the exhaust gas returned by inhalation of air during an overlap period, or gas which remains in a cylinder], it is not necessarily efficient.
[0011] On the other hand, only by compression of a piston, it is made for self-ignition not to occur in JP,10-196424,A, and temperature is raised to it near the compression top dead center of a piston with other means, and it has invention which it is stabilized [invention] and makes self-ignition cause. According to this, the cycle in which a compression ratio and the amount of EGR(s) are insufficient for, and self-ignition does not occur in a middle compression ratio can also cause self-ignition, but in fact, this engine's fundamental compression ratio cannot but be so low that self-ignition does not break out, therefore the thermal efficiency of a cycle cannot but become low.
[0012] In order to make high the heat efficiency of internal combustion engine, this invention is aiming at the internal combustion engine which makes operation possible with the high compression ratio, and cannot attain the purpose with a means by which the thermal efficiency of a cycle falls.
[0013] That is, at the time of self-ignition operation, as much as possible, in a high compression ratio, the aim which realizes the internal combustion engine which makes cycle thermal efficiency high as much as possible is in this invention, and the feature peculiar to this invention which must be operated with a compression ratio lower than usual it occurs in fields other than a self-ignition operating range in connection with it.
[0014] that is, it is the premise of this invention that the compression ratio of a base engine turns into a high compression ratio with high cycle thermal efficiency to which it appears so much and self-ignition happens at the time of self-ignition operation, this is a big difference point with JP,10-196424,A, and it is clear that the purpose of this invention cannot be attained with the means in JP,10-196424,A.
[0015] Of course, although the internal combustion engine which utilizes both a compression ratio and internal EGR is also considering as the object in this invention in order to make self-ignition cause, internal EGR is in a cylinder from from, before supplying working medium, and keeps the gas temperature in a cylinder high. In the case of direct injection which cannot say that a temperature rise is additionally given to a combustible gas mixture, and is in this invention, as not the temperature rise of a combustible gas mixture but an operation of internal EGR gas, since this will raise inhalation air temperature, it is clear that it is not raising temperature additionally about the combustible gas mixture.
[0016] Since this invention has the time lag of a change means under the above conditions at the time of the change of self-ignition operation and jump-spark-ignition operation In some transitional cycles, the effective compression ratio and the amount of EGR(s) of the cycle become in-between. Knocking occurs

without self-ignition breaking out. To an operator or a fellow passenger [that it is unpleasant and] Engine stability is spoiled and operability may get worse, and when the degree of knocking is intense, it aims at solving the trouble that damage on an engine may be occurred.
[0017]
[Means for Solving the Problem] For this reason, in invention concerning claim 1, as shown in drawing 1 , it sets to a combustion control system of an internal combustion engine which performs jump-spark-ignition combustion in self-ignition combustion and a heavy load at a low compression ratio in a low load with a high compression ratio. In a middle compression ratio cycle at the time of a change of self-ignition combustion and jump-spark-ignition combustion, it is characterized by establishing a change tense means to make self-ignition combustion perform at a low compression ratio side of a change region by high compression ratio side of jump-spark-ignition combustion which adjusted ignition timing, and a change region.
[0018] In invention concerning claim 2, in invention concerning claim 1, it is characterized by adjusting fuel oil consumption with a fuel-oil-consumption adjustment means at a low compression ratio side of said change region so that generating torque may serve as abbreviation identitas with an ignition timing adjustment means, while delaying ignition timing.
[0019] In invention concerning claim 3, the amount of delay of ignition timing is characterized by making it so large that a compression ratio being high in invention concerning claim 2. In invention concerning claim 4, it is characterized by raising working medium temperature with a working medium temperature rise means in invention concerning claims 1-3 at a high compression ratio side of said change region.
[0020] In invention concerning claim 5, said working medium temperature rise means is characterized by being what injects an additional fuel by expansion stroke of a piston in invention concerning claim 4.
[0021] In invention concerning claim 6, in invention concerning claim 4, it has an adjustable moving valve mechanism adjusted so that overlap of an inlet valve and an exhaust valve may be subtracted at the time of self-ignition combustion, and said working medium temperature rise means is characterized by being what injects an additional fuel by expansion stroke of a piston. Here, it says that overlap of minus establishes a period when a comb and an open stage of an inlet valve were made at later than a top dead center, and both an inlet valve and an exhaust valve have already closed a close stage of an exhaust valve near the top dead center from a top dead center.
[0022] It has an adjustable moving valve mechanism adjusted so that overlap of an inlet valve and an exhaust valve may be subtracted in invention concerning claim 4 at the time of self-ignition combustion, and said working-medium temperature rise means injects an additional fuel by up stroke of a piston in a minus overlap period, and an ignition plug operates during a minus overlap period, and it carries out that it is what burns an additional fuel as the feature by invention concerning claim 7.
[0023] In invention concerning claim 8, additional fuel oil consumption is characterized by making it so few that a compression ratio being high in invention concerning claims 5-7. In invention concerning claim 9, additional fuel oil consumption is characterized by making it so few that there being many amounts of EGR(s) in invention concerning claims 5-8.
[0024] In invention concerning claim 10, it is characterized by also lighting a high compression ratio side of said change region, and delaying the ignition timing, so that a compression ratio is high in invention concerning claims 1-9.
[0025] In invention concerning claim 11, a compression ratio at the time of self-ignition combustion is characterized by considering as a compression ratio in which self-ignition combustion is possible only by it in invention concerning claims 1-10.
[0026]
[Effect of the Invention] Since both operating range can shift smoothly, without knocking occurring during the change of self-ignition combustion and jump-spark-ignition combustion by making self-ignition combustion perform in the middle compression ratio cycle at the time of the change of self-ignition combustion and jump-spark-ignition combustion by the high compression ratio side of the jump-spark-ignition combustion which adjusted ignition timing in the low compression ratio side of a

change region, and a change region according to invention concerning claim 1, the effect that good operability and silence can acquire is acquired.
[0027] While delaying ignition timing, knocking is not only avoidable, but the stable rotation is securable by the low compression ratio side of a change region, according to invention concerning claim 2, by adjusting fuel oil consumption so that generating torque may serve as abbreviation identitas.
[0028] According to invention concerning claim 3, the amount of delay of ignition timing can make a knocking sparing effect suitable by making it so large that a compression ratio being high. According to invention concerning claim 4, it can be stabilized and self-ignition can be made to cause by raising working medium temperature with a working medium temperature rise means in the high compression ratio side of a change region.
[0029] According to invention concerning claim 5, working medium temperature can be raised certainly, it can be stabilized, and self-ignition can be made to cause by injecting an additional fuel by the expansion stroke of a piston.
[0030] Working medium temperature can be raised still more certainly, it can be stabilized, and self-ignition can be made to cause by injecting an additional fuel by the expansion stroke of a piston, after according to invention concerning claim 6 adjusting so that it may become overlap of minus at the time of self-ignition combustion.
[0031] Working medium temperature can be raised still more certainly, it can be stabilized, and self-ignition can be made to cause by injecting an additional fuel by the up stroke of the piston in a minus overlap period, and operating an ignition plug during a minus overlap period, and burning an additional fuel, after according to invention concerning claim 7 adjusting so that it may become overlap of minus at the time of self-ignition combustion.
[0032] According to invention concerning claim 8, additional fuel oil consumption is making it so few that a compression ratio being high, and can be controlled appropriately. According to invention concerning claim 9, additional fuel oil consumption is making it so few that there being many amounts of EGR(s), and can be controlled appropriately.
[0033] According to invention concerning claim 10, the high compression ratio side of a change region is also lit, and by delaying, so that a compression ratio is high, even when self-ignition does not break out, the ignition timing can make combustion able to cause by jump spark ignition, and can prevent aggravation of operability or exhaust air.
[0034] According to invention concerning claim 11, the compression ratio at the time of self-ignition combustion can make thermal efficiency high as much as possible by considering as the compression ratio in which self-ignition combustion is possible only by it.
[0035]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained. Drawing 2 is the schematic diagram of the internal combustion engine which shows 1 operation gestalt of this invention.
[0036] If a configuration is explained first, opening of a suction port 4 and the exhaust air port 5 is equipped with the inlet valve 6 and the exhaust valve 7 in the combustion chamber 3 formed by an engine cylinder 1 and an engine piston 2. Moreover, while having the ignition plug 8 for jump spark ignition so that a combustion chamber 3 may be attended, it has the fuel injection valve 9 of a direct injection type.
[0037] Both the actuation period of the inlet valve 6 by each cam and an exhaust valve 7 and the amount of lifts are prepared in the controllable adjustable moving valve mechanisms 10 and 11 by each cam shaft which drives an inlet valve 6 and an exhaust valve 7. In addition, as an actuator of the adjustable moving valve mechanisms 10 and 11, oil pressure or an electric motor is used, for example.
[0038] Thereby, as shown in drawing 3 (1) at the time of the usual jump-spark-ignition operation, the close stage of an exhaust valve is early made later [than a top dead center (TDC)] than a top dead center for the open stage of an inlet valve, overlap of an inlet valve and an exhaust valve is given, the close stage of an inlet valve is made later than a bottom dead point (BDC), and a compression ratio is set at coincidence to the low compression ratio (about [for example,] 10) of the degree which does not

knock.
[0039] At the time of self-ignition operation, by control of the actuation period of an inlet valve and an exhaust valve, and the amount of lifts, as shown in drawing 3 (4), the open stage of an inlet valve is early made later [than a top dead center] than a top dead center for the close stage of an exhaust valve, and minus overlap is established. That is, when a part of closing and exhaust gas are stopped in a cylinder in the middle of an exhaust stroke (internal EGR), an exhaust valve is compressed and expanded before and behind a top dead center and cylinder internal pressure becomes a suction-port pressure degree, an inlet valve is opened and new air is inhaled in a cylinder. Thereby, new air is heated by the residual gas of the cycle in front of one of them. The close stage of an inlet valve sets a compression ratio as near a bottom dead point at coincidence to a high compression ratio (the maximum effective compression ratio in this engine) (about [for example,] 15). Therefore, since new air can take a high compression ratio while being heated with residual gas, it becomes able [the temperature and the pressure near a compression top dead center] to reach level which makes self-ignition cause stably.
[0040] Although it is made to perform both the Maine injection which is a direct injection type and this mentions later, and auxiliary injection, a fuel injection valve 9 prepares the fuel injection valve which injects a fuel by the suction port 4, and the fuel injection valve of a direct injection type, and the fuel injection valve by the side of a suction port may perform Maine injection, and it may be made to perform auxiliary injection by the fuel injection valve of a direct injection type.
[0041] It connects with the control unit which is not illustrated and the adjustable moving valve mechanisms 10 and 11 of the inlet valve 6 besides an ignition plug 8 and a fuel injection valve 9 and an exhaust valve 7 are controlled based on the signal from this control unit.
[0042] A control unit inputs signals, such as an engine speed and accelerator pedal opening (torque), and distinguishes a self-ignition operating range by the side of a low load as shown in drawing 4 , and a jump-spark-ignition operating range by the side of a heavy load. Furthermore, the signal which carries out the monitor of the actuation of an inlet valve 6 or an exhaust valve 7 is inputted, for example, calculation of calculation of the effective compression ratio for every cycle, and the open stage of an inlet valve and the close stage of an exhaust valve to the amount of overlap and calculation of the amount of internals EGR are performed from the close stage of an inlet valve.
[0043] Next, an operation is explained. First, in drawing 5 , the case where the transient-characteristic action in the case of the conventional internal combustion engine is shifted to a self-ignition operating range from a jump-spark-ignition operating range is taken and explained to an example. When shifting to a jump-spark-ignition operating range from a self-ignition operating range, the reverse of drawing 5 will be followed.
[0044] In the time of day T0 of drawing 5 , a judgment which shifts to self-ignition is made by the control unit, and a self-ignition indication signal serves as On. Although actuators, such as oil pressure or an electric motor, begin to move in an adjustable moving valve mechanism and the compression ratio and the amount of EGR(s) (the amount of internals EGR) change for every cycle in order to change actuation of an inlet valve and an exhaust valve according to it The delay in the following cycle used as On, most of a compression ratio or the amount of EGR(s) is still still in the state at the time of jump-spark-ignition operation, and according to the actuation duration (T0 - T3) of an actuator sake, It becomes time-of-day T3 of for example, 8 cycle eye for a compression ratio and the amount of EGR(s) to change gradually for every cycle, and for self-ignition to be stabilized finally, and to happen.
[0045] In the time of day T1 of drawing 5 , since a compression ratio and the amount of EGR(s) increase a little highly, if a jump-spark-ignition stage remains as it is, knocking takes place. If shift of a cam is then continued, in time of day T2, a compression ratio and the amount of EGR(s) will reach the level which makes self-ignition cause, self-ignition will happen, and knocking will be lost.
[0046] That is, from this time of day T1 before T2 becomes a problem. In the meantime, while a compression ratio and the amount of EGR(s) are in the process which increases highly, respectively, for causing self-ignition, it is insufficient, and in with a setup with a low compression ratio of ignition timing, it is the field from which knocking is started.
[0047] An operation of this invention is shown in drawing 6 . This invention is observing between time

of day T1 and T2, and divides during this period into a low compression ratio [in a middle compression ratio], and high compression ratio side by dividing into two. It considers as the time of day which kicks time-of-day T four that much.
[0048] Between time of day T1 and T four (on control between time of day T0 and T four), since it is in the closing motion condition of the induction-exhaust valve in the middle of a change as shown in drawing 3 (2), there are also still few amounts of a compression ratio and EGR(s) comparatively low. Therefore, although jump spark ignition is carried out, the retard (delay) of the ignition timing is carried out. Under the present circumstances, as shown in drawing 7 , the compression ratio which serves as a knocking limit by ignition timing retard becomes high, and knocking can be avoided.
[0049] As similarly shown in drawing 7 on the other hand, in order that [the] a heat release stage may be overdue with ignition timing retard, cycle efficiency gets worse and torque decreases. Therefore, the torque decrement deltaTorque In order to compensate, the quantity of the Maine injection quantity Qmain in an intake stroke is increased. An air-fuel ratio becomes a rich side by this, and a knocking sparing effect can also be enlarged further. It cannot so be overemphasized that an increased part of this Maine injection quantity Qmain is so close to T four that [that is,] a compression ratio is high that it is made [many].
[0050] Next, since it will become the actuation condition of the induction-exhaust valve in the middle of a change as shown in drawing 3 (3) between time-of-day T four and T2 (on control between time-of-day T four and T3) if it becomes time-of-day T four namely, a compression ratio and the amount of EGR(s) increase comparatively highly. Therefore, with an auxiliary working medium temperature rise means, working medium temperature is raised and carries out self-ignition combustion.
[0051] Drawing 6 shows the example which raises an exhaust-gas temperature as a working medium temperature rise means using a means to inject an additional fuel (auxiliary fuel), by the expansion stroke of a piston. Additional fuel oil consumption Qadd (expansion-stroke injection quantity) Near T four, its weight is reduced after it, and it becomes zero by time-of-day T3 which a change completes. This is for reaching such sufficient level that it increasing highly and self-ignition happening by T2 before time-of-day T3 as a compression ratio and the amount of EGR(s) become T3 from T four.
[0052] As further shown in details at drawing 8 , an auxiliary fuel is injected by the expansion stroke and, thereby, an exhaust-gas temperature becomes high. Although an effect is hard to be acquired only by exhaust gas not turning to the following cycle so much as residual gas, but carrying out expansion-stroke injection since there is little overlap, usually, with this operation gestalt Since it is considering as minus overlap, as shown in drawing 3 (3), between T four and T3, minus overlap becomes quite large, the trap of many parts is certainly carried out into a cylinder from that of exhaust gas, and the working medium temperature of the following cycle can be raised considerably. Therefore, in this invention, the working medium temperature rise of the following cycle is effectively realizable by considering as a minus overlap configuration with expansion-stroke injection.
[0053] Moreover, in this case, as shown in drawing 6 and drawing 8 , jump spark ignition is also used together. The retard of it is carried out, so that the ignition timing of this jump spark ignition has so many amounts of EGR(s) that a compression ratio is high, and it is set up behind the top dead center by drawing 8 . This is for preventing continuing turning and aggravation of operability or exhaust air taking place, without making combustion cause by jump spark ignition, and an engine carrying out a flame failure, even when self-ignition does not break out.
[0054] Furthermore, an additional fuel (auxiliary fuel) is injected to drawing 9 by the up stroke of the piston in a minus overlap period as another working medium temperature rise means, and an ignition plug is operated to it during a minus overlap period, and the example using a means to burn an additional fuel is indicated to be expansion-stroke injection to it.
[0055] This is for raising the temperature of EGR gas further, heating new air enough also in the small amount of EGR(s), and making it make self-ignition cause by injecting directly and carrying out jump spark ignition of the fuel, and burning it during a minus overlap period.
[0056] This auxiliary fuel injection is the period when a piston goes up by the exhaust stroke, and is timing which the injected fuel does not blow from an exhaust valve, and is injected during a minus

overlap period. Desirably, it takes for the neighborhood 70 degrees from 30 degrees in front of a top dead center.
[0057] Ignition is performed during minus overlap and it is desirably carried out before and behind a top dead center. If it lights not much early, since engine minus work will increase, it is desirably set up so that it may be lit after 30 degrees in front of a top dead center.
[0058] Such an auxiliary working medium temperature rise means is peculiar to a minus overlap configuration, and since all injection fuels are used for the temperature rise of EGR gas, it is efficient. Moreover, by choosing ignition timing, heat release is carried out behind a top dead center, plus is worked to a piston, and there is the feature as for which fuel consumption aggravation by auxiliary fuel injection is made to the minimum. Moreover, there is much injection quantity, and since unburnt [the / which was generated / HC] has the operation which causes the self-ignition of the cycle easily in reverse as a combustion intermediate product although unburnt [HC] generates when there is little oxygen of EGR gas, it is convenient. Therefore, the injection quantity of this auxiliary fuel is also the expansion-stroke injection quantity Qadd of drawing 6 . Similarly, near T four, at the maximum, it decreases as T3 is approached, and in T3, it is set up so that it may become zero.
[0059] In case it switches from high compression ratio self-ignition operation mode to low compression ratio jump-spark-ignition operation mode, the above-mentioned reverse is performed. Drawing 10 shows the above-mentioned control with a flow chart.
[0060] Step 1 (it is described in drawing as S1.) Distinguishing a operating range in it being the same as that of the following, in by the side of a heavy load, it progresses to step 2, and it performs jump-spark-ignition control with a low compression ratio. Moreover, in the case of a low load, it progresses to step 3, and it performs the self-ignition combustion control in a high compression ratio.
[0061] Moreover, it judges whether it is the change region of jump-spark-ignition combustion and self-ignition combustion, and, in the case of a change region, controls by step 4 as follows (change tense means). A real compression ratio is judged at step 5, and, in by the side of a low compression ratio, the retard of the ignition timing is carried out at step 6 (ignition timing adjustment means). Moreover, the quantity of the Maine injection quantity is increased at step 7 (fuel-oil-consumption adjustment means).
[0062] In by the side of a high compression ratio, working medium temperature is raised at step 8 by expansion-stroke injection, or the injection and ignition during a minus overlap period (working medium temperature rise means). Moreover, jump spark ignition is used together at step 9.
[0063] As explanation of this invention, although the example of the minus overlap configuration of drawing 3 has explained, the system (valve timing does not change) of only a mechanical adjustable compression ratio can be considered as an internal combustion engine's example accompanied by other self-ignition operating range. Also in this case, although it can respond by ignition timing retard, if a compression ratio goes up more, any longer, by ignition timing retard, an output can decline and cannot respond the first stage which the compression ratio goes up. Moreover, although the effect is controlled even if the amount of residual gas raises many exhaust-gas temperatures, since valve timing is not changed, the facilitatory effect of self-ignition is acquired. Even in this case, the following operations are performed.
[0064] Since it becomes easy to knock from immediately after change directions as a compression ratio goes up in case it switches from low compression ratio jump-spark-ignition operation mode to high compression ratio self-ignition operation mode, ignition timing is delayed, and jump spark ignition is carried out, controlling knocking.
[0065] Furthermore, the temperature of the residual gas of following SAIKURUHE is raised, and the self-ignition in the following cycle is made to inject an additional fuel to a piston expansion stroke, to make combustion cause, and to cause, if a compression ratio goes up even if it is not sufficient high compression ratio.
[0066] Furthermore, if a compression ratio goes up, additional fuel injection will be stopped. It means completing the shift to self-ignition operation mode at this time. Since the intake-air temperature all whose additional injection fuels are the following cycles is not raised compared with the system of minus overlap, the temperature rise effectiveness is inferior.

[0067] However, self-ignition combustion is realizable by making the speed of response of a compression ratio practically sufficiently quick, carrying out knocking control. In case it switches from high compression ratio self-ignition operation mode to low compression ratio jump-spark-ignition operation mode, the above-mentioned reverse is performed.
[0068] Moreover, a compression ratio may be adjusted by twisting the cam shaft of an inlet valve as other examples. In this case, with a low compression ratio, there is little bulb overlap, in a high compression ratio, bulb overlap becomes large and its residual gas increases more. In this case, if it can respond by the retard of ignition timing and a compression ratio goes up more the first stage which the compression ratio goes up, the amount of overlap is also large at coincidence. For this reason, self-ignition can be caused, even if the intake-air temperature of the following cycle also rises and a compression ratio does not go up completely, since there are many amounts of residual gas of following SAIKURUHE when the temperature of exhaust gas is raised.
[0069] Since it becomes easy to knock from immediately after change directions as a compression ratio goes up in case it switches from low compression ratio jump-spark-ignition operation mode to high compression ratio self-ignition operation mode, ignition timing is delayed, and jump spark ignition is carried out, controlling knocking.
[0070] Furthermore, the temperature of the residual gas of following SAIKURUHE is raised, and the self-ignition in the following cycle is made to inject an additional fuel to a piston expansion stroke, to make combustion cause, and to cause, if a compression ratio goes up even if it is not sufficient high compression ratio. Since the amount of bulb overlap has also increased at this time, the inhalation-of-air gas temperature of the following cycle also rises. For this reason, self-ignition can be caused even if a compression ratio does not rise completely.
[0071] Furthermore, if a compression ratio goes up, since self-ignition happens, only a compression ratio will stop additional fuel injection. It means completing the shift to self-ignition operation mode at this time. Since the intake-air temperature all whose additional injection fuels are the following cycles is not raised compared with the system of minus overlap, the temperature rise effectiveness is inferior, but if valve timing compares with the still same mechanical adjustable compression ratio system, temperature rise effectiveness is high.
[0072] In case it switches from high compression ratio self-ignition operation mode to low compression ratio jump-spark-ignition operation mode, the above-mentioned reverse is performed. as mentioned above, in the combustion control system of the internal combustion engine concerning this operation gestalt While carrying out the retard of the ignition timing by the ignition plug in a low compression ratio side and controlling knocking in the middle compression ratio in the middle of a change in the time of the change of operation of the self-ignition of a high compression ratio, and jump spark ignition of a low compression ratio Since it can shift to self-ignition, without knocking occurring during a change since working medium temperature is raised with an auxiliary and temporary means in a high compression ratio side and it was made to make self-ignition cause, the effect that good operability and silence are maintained is realized.
[0073] Since self-ignition is stabilized, it can realize as this result and the throttle valve prepared in the middle of the inhalation-of-air path like before does not need to restrict the amount of the new mind inhaled at the time of a partial load, reduction of the pumping loss resulting from inhalation negative pressure is attained.
[0074] Since a compression ratio and the amount of EGR(s) move in [both] making it a minus overlap configuration especially at the time of self-ignition, the effect that an exhaust-gas-temperature rise or the ignition to the auxiliary injection fuel in an inhalation-of-air top dead center is effectively used for the rise of the working medium temperature of the following cycle is acquired. However, the effect according to this invention also in the engine of a configuration of not making it minus overlap is acquired enough practically.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The combustion control system of the jump-spark-ignition combustion which adjusted ignition timing by low compression ratio side of a change region in a middle compression ratio cycle at the time of a change of self-ignition combustion and jump-spark-ignition combustion in a combustion control system of an internal combustion engine which performs jump-spark-ignition combustion with a low compression ratio in self-ignition combustion and a heavy load in a low load with a high compression ratio, and the internal combustion engine characterized by to establish a change tense means make self-ignition combustion perform in a high compression ratio side of a change region.
[Claim 2] A combustion control system of an internal combustion engine according to claim 1 characterized by adjusting fuel oil consumption with a fuel-oil-consumption adjustment means so that generating torque may serve as abbreviation identitas with an ignition timing adjustment means in a low compression ratio side of said change region, while delaying ignition timing.
[Claim 3] The amount of delay of ignition timing is the combustion control system of an internal combustion engine according to claim 2 characterized by making it so large that a compression ratio being high.
[Claim 4] A combustion control system of an internal combustion engine of any one publication of claim 1 characterized by raising working medium temperature with a working medium temperature rise means in a high compression ratio side of said change region - claim 3.
[Claim 5] Said working medium temperature rise means is the combustion control system of an internal combustion engine according to claim 4 characterized by being what injects an additional fuel by expansion stroke of a piston.
[Claim 6] It is the combustion control system of an internal combustion engine according to claim 4 which has an adjustable moving valve mechanism adjusted so that overlap of an inlet valve and an exhaust valve may be subtracted at the time of self-ignition combustion, and is characterized by said working medium temperature rise means being what injects an additional fuel by expansion stroke of a piston.
[Claim 7] It is the combustion control system of an internal combustion engine according to claim 4 characterized by being what it has [what] an adjustable moving valve mechanism adjusted so that overlap of an inlet valve and an exhaust valve may be subtracted at the time of self-ignition combustion, and said working medium temperature rise means injects [what] an additional fuel by up stroke of a piston in a minus overlap period, and operates an ignition plug during a minus overlap period, and burns an additional fuel.
[Claim 8] Additional fuel oil consumption is the combustion control system of an internal combustion engine of any one publication of claim 5 characterized by making it so few that a compression ratio being high - claim 7.
[Claim 9] Additional fuel oil consumption is the combustion control system of an internal combustion engine of any one publication of claim 5 characterized by making it so few that there being many amounts of EGR(s) - claim 8.

[Claim 10] It is the combustion control system of an internal combustion engine of any one publication of claim 1 characterized by also lighting a high compression ratio side of said change region, and delaying the ignition timing, so that a compression ratio is high - claim 9.
[Claim 11] A compression ratio at the time of self-ignition combustion is the combustion control system of an internal combustion engine of any one publication of claim 1 characterized by considering as a compression ratio in which self-ignition combustion is possible only by it - claim 10.

[Translation done.]

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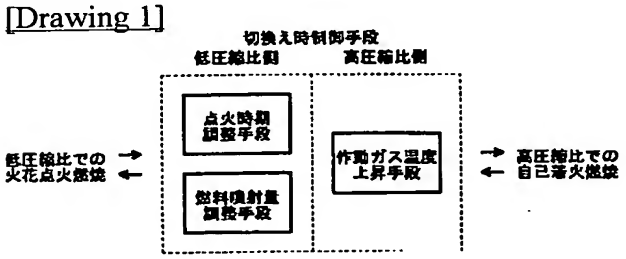
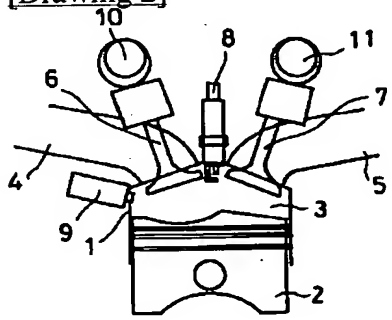
DRAWINGS

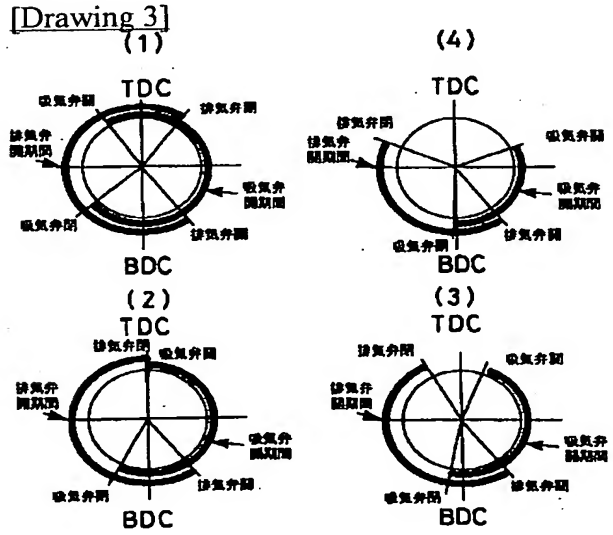
[Drawing 1]



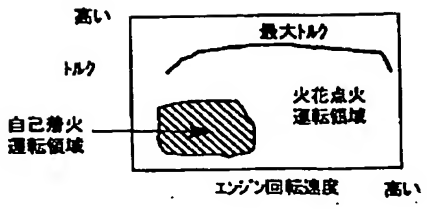
[Drawing 2]



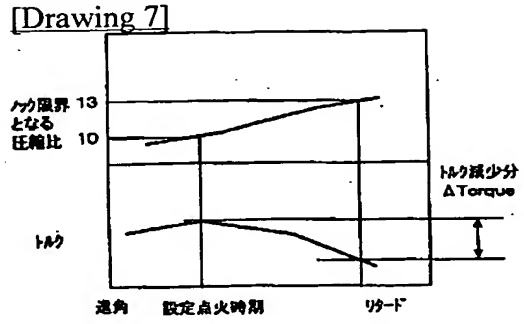
[Drawing 3]



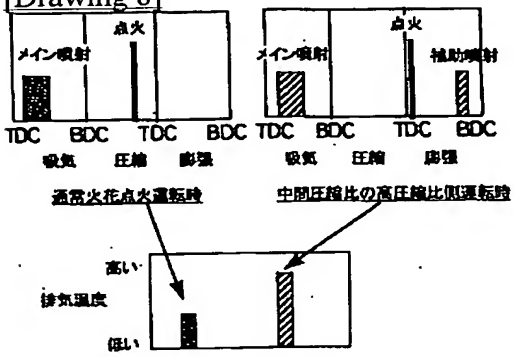
[Drawing 4]



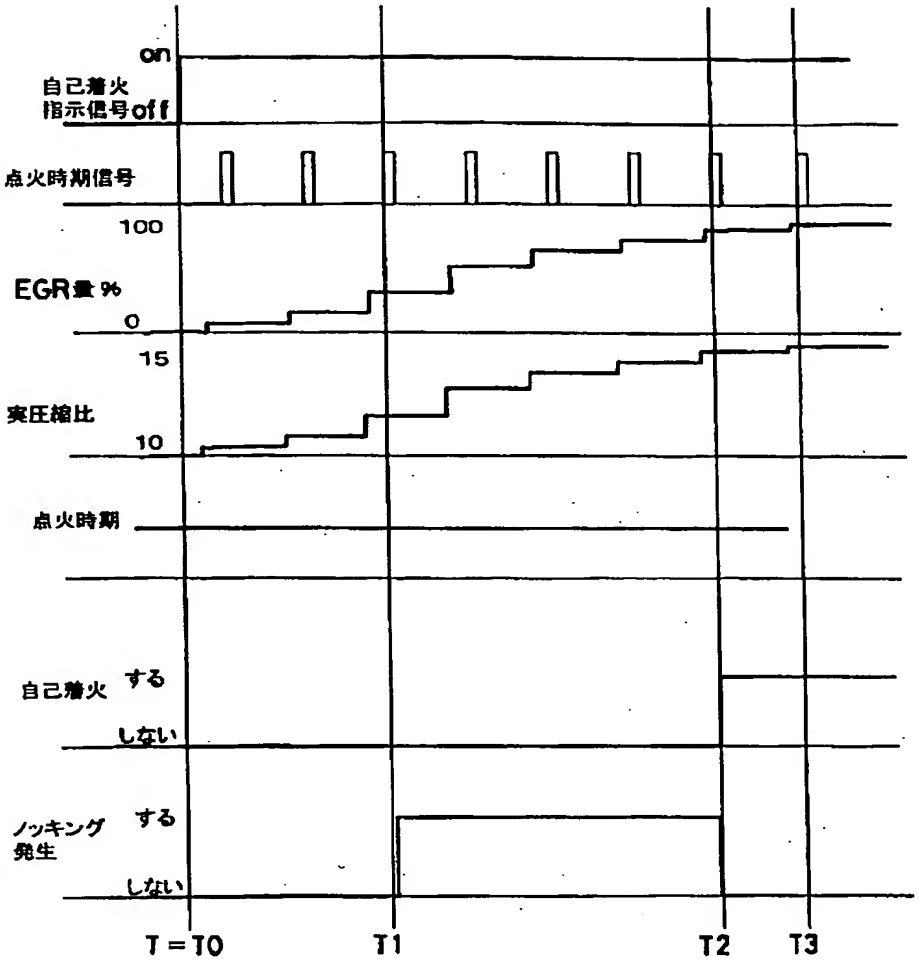
[Drawing 7]



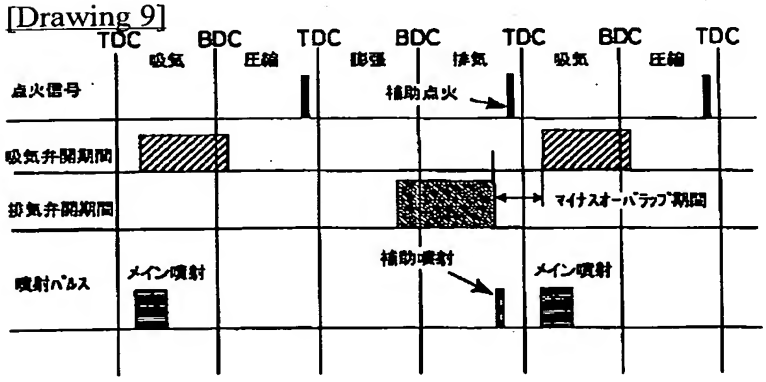
[Drawing 8]



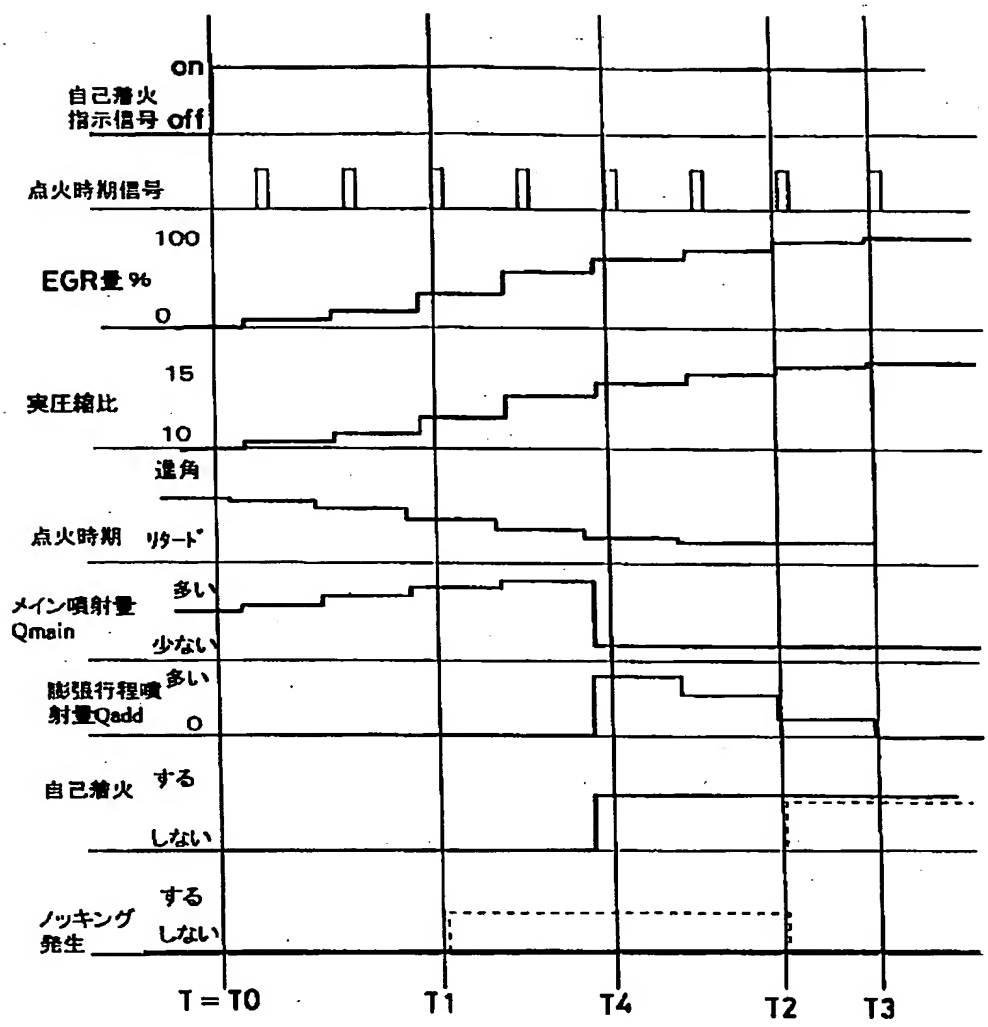
[Drawing 5]



[Drawing 9]



[Drawing 6]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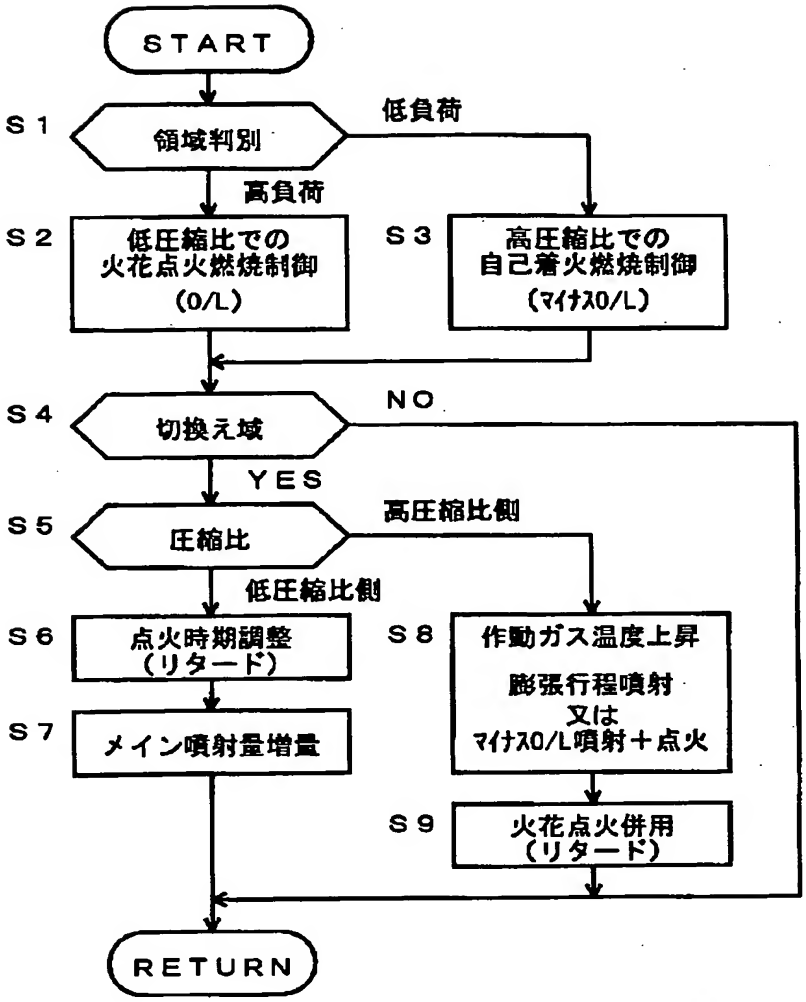
[Drawing 10]



[Translation done.]